EE HPC Workshop
O&G Panel

Nov 2015

Passion for Geoscience

CGG

Outline

- CGG

- Marine Acquisition 1995 – 2015

- Seismic Processing Datacenters

- Oil Immersion with Green Revolution Cooling

CGG: O&G Service Segment

- ## Sercel
  - Started in 1956
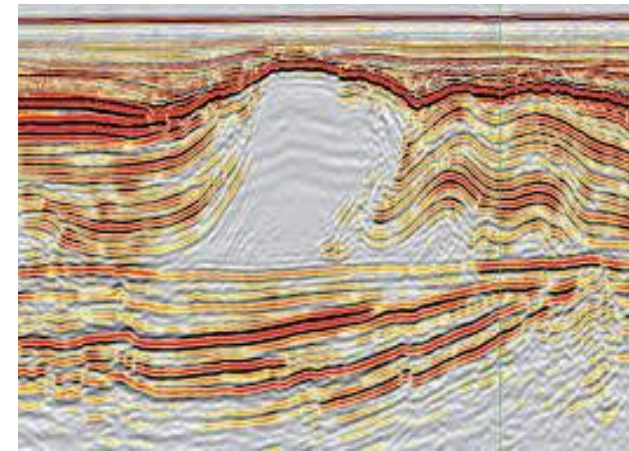 - Produces seismic sensors

- ## Marine/Land
  - Started in 1931
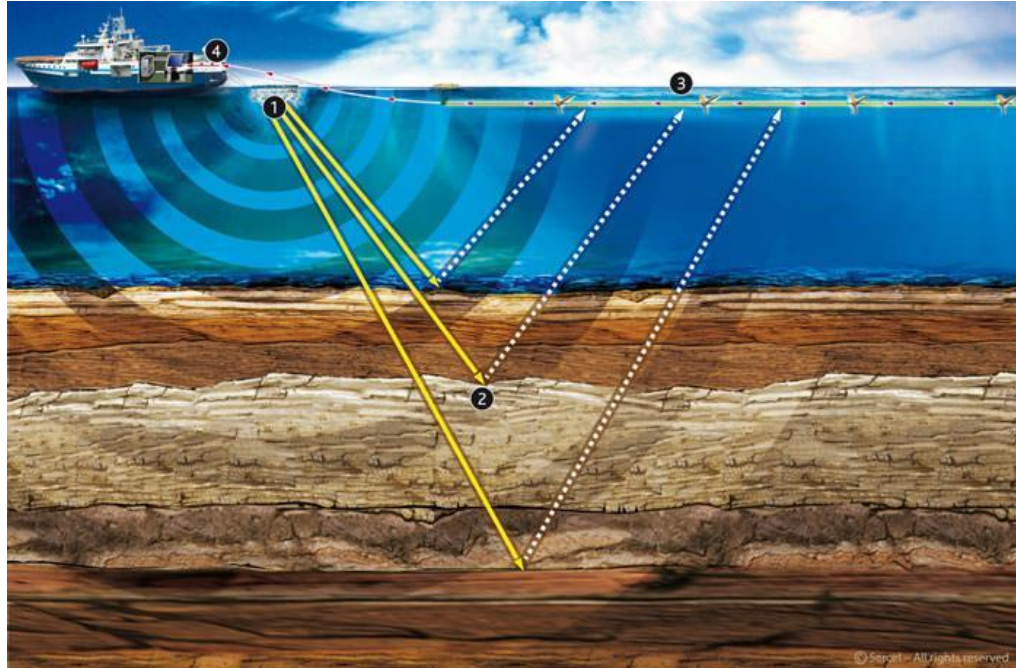 - Acquires seismic data

- ## Subsurface Imaging
  - Processes & interprets data
  - *Very cost sensitive*
  - *Every compute job is revenue*

Acquisition: The Basic Idea
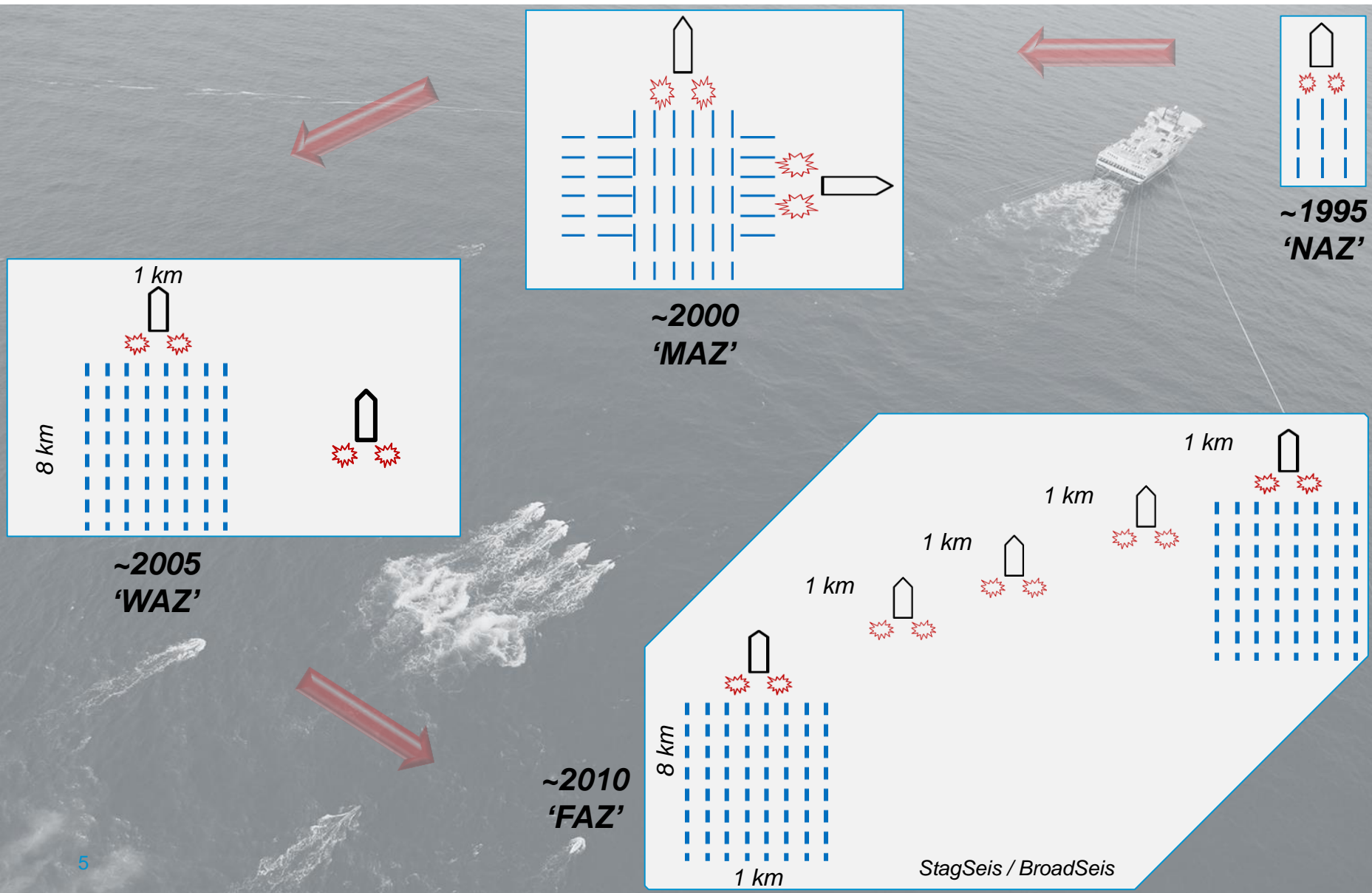

High power sound waves reflect off of rock layers

Reflected sound waves are recorded by towed 'streamers' / hydrophones

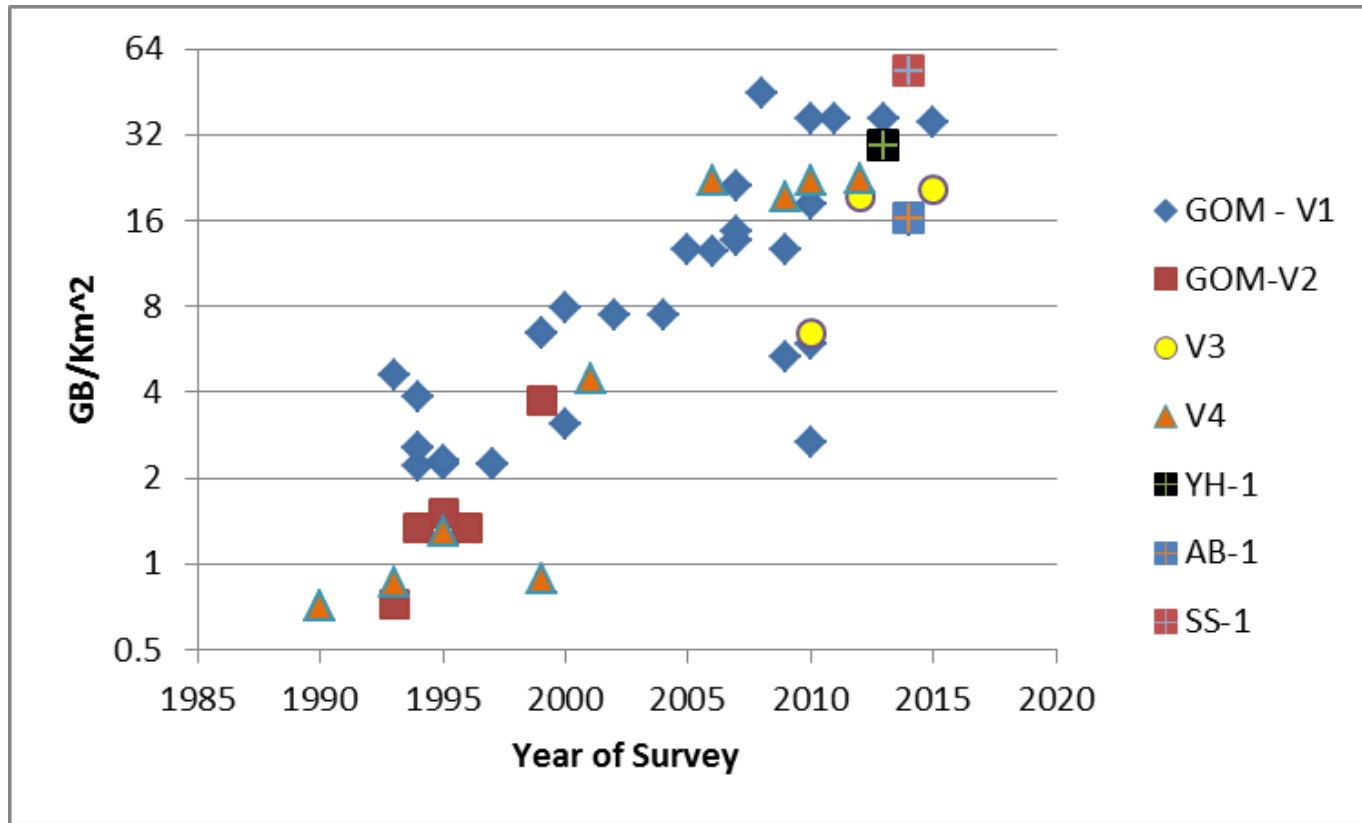*The recorded signal is used to produce an 'image' of rock layers*

(More details are in the backup slides)

Acquisition: Marine Surveys Over Time

~1995
'NAZ'

~2000
'MAZ'

~2005
'WAZ'

1 km

8 km

~2010
'FAZ'

1 km

1 km

1 km

1 km

1 km

8 km

1 km

StagSeis / BroadSeis

5

Acquisition: Data Volumes Over Time

Marine data volumes double every ~ 3-5 years

(These are very rough estimates from online sources)

CGG Seismic Processing Datacenters

- Workload
  - Data volumes are doubling every few years
  - Computational intensity is growing even faster (TOTAL slide)
  - Good news for CGG: *embarrassingly parallel thus far*

- Datacenters
  - Two large sites: Houston, London
    - 1000's of GPUs per site
    - 10,000's of CPU sockets per site

- Cooling
  - *London uses 'free air' cooling*
  - *Houston uses traditional CRAC cooling*
  - *Houston also uses oil immersion cooling*

Oil Immersion: Cost Savings
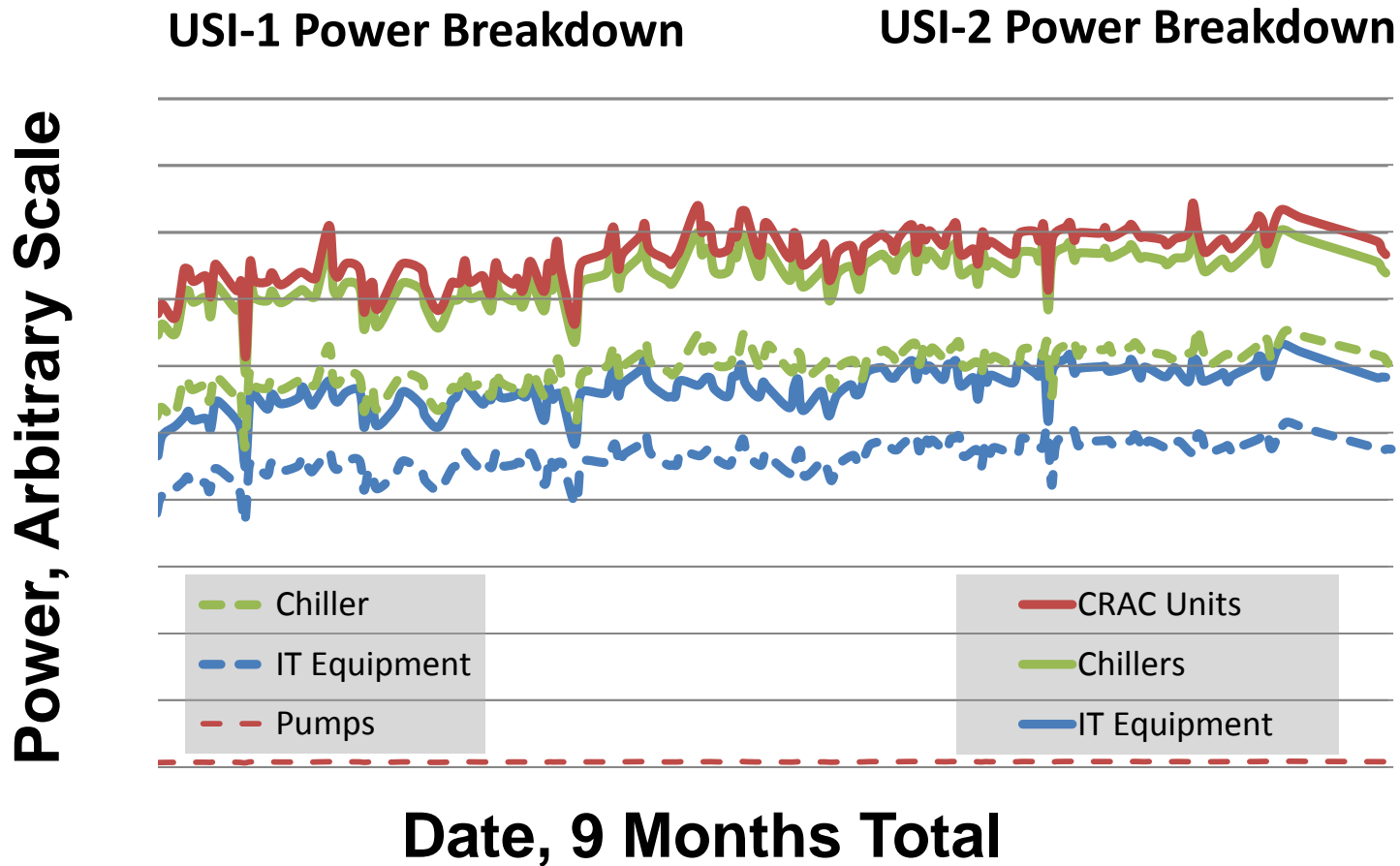
- ## CapEx

  - **Scenario: upgrade PUE ~ 2 datacenter**
    - *Savings are very business case dependent*
    - *Much of the total savings is here*

  - CapEx Avoided: use lower cost oil gear
    - Several considerations here (downtime, labor, etc)

  - CapEx Deferral: free up power
    - Convert CRAC unit power to compute power
    - Pushes out CapEx to add power by a few years

- ## OpEx

  - What are we comparing to?
    - USI2, air cooling, PUE* ~ **1.33 – 1.38**

  - Note problems with power instrumentation
   - *Much of the savings is in removing the systems fans*

Oil Immersion: Cost Savings

USI-1 Power Breakdown   **USI-2 Power Breakdown**

Power, Arbitrary Scale

Date, 9 Months Total

Legend:
- Chiller
- IT Equipment
- Pumps
- CRAC Units
- Chillers
- IT Equipment

Oil Immersion: Challenges & Surprises

- **Challenges**

  - Multiple oil specific failure modes

    - Example: no optics (plastic)

    - These *can* be fixed

  - Oil is messy

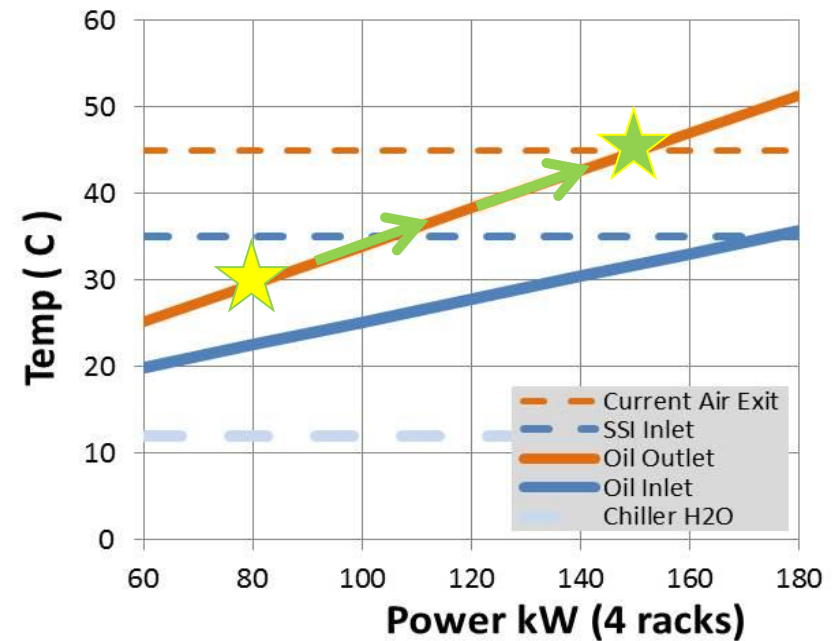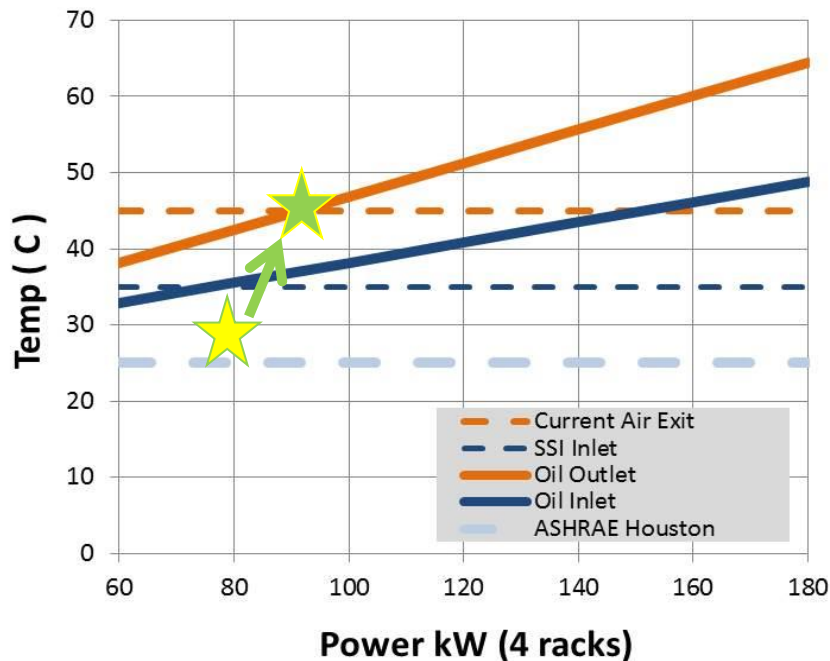   - But not that bad day to day

  - Lower Density

    - 25% - 50% **
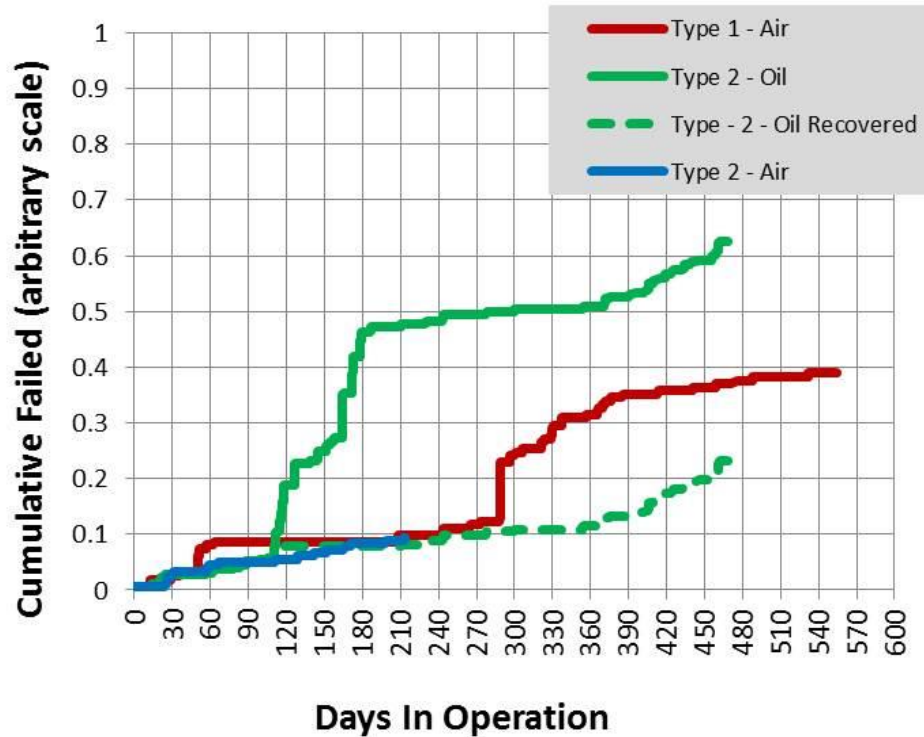
- **Surprises**

  - Oil & Air failure rates are roughly the same

  - *Peak component temperatures are 20C lower for oil vs air*

  - Thermal Inertia

    - Ride through of 45 minutes on loss of chilled water

  - It sure is quiet in here

Oil Immersion – Next Steps

- Increase the Density
  - Need *commodity* systems @ 1kW / U
  - Move to above 40kW per rack

- Eliminate the Chillers
  - Estimate can operate 90% of Houston ASHRAE hours on cooling tower water

Backup & Older

An Integrated Geoscience Company

Equipment

Full range of products and clear market leadership onshore, offshore and downhole:

- Technology leadership
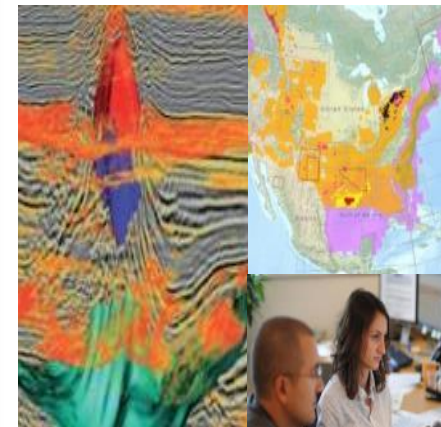- Large installed base
- A cornerstone for CGG integrated solutions

Acquisition

Full range of seismic and other geophysical methods for acquisition:

- Marine
- Land
- Multi-Physics
- Seabed*

Geology, Geophysics & Reservoir

- Subsurface Imaging
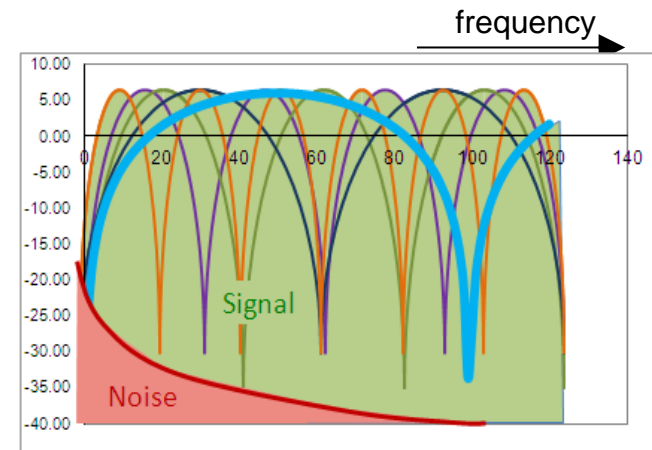- GeoConsulting
- GeoSoftware
- Multi-Client & New Ventures
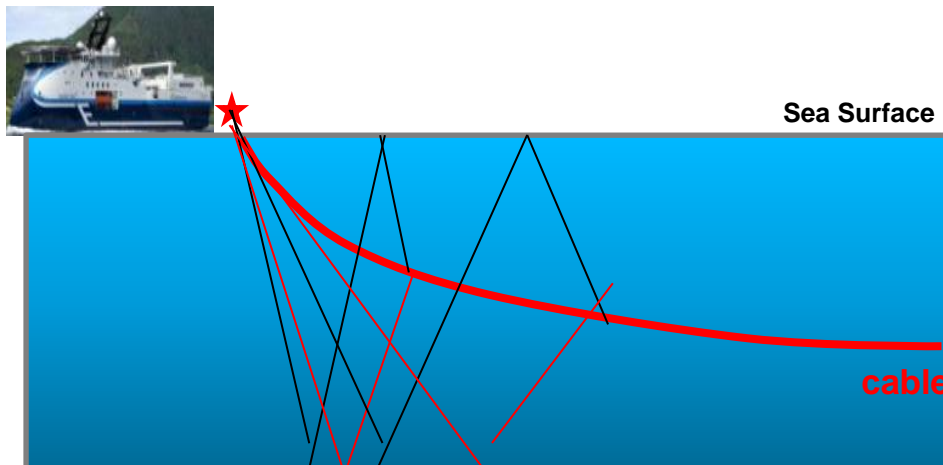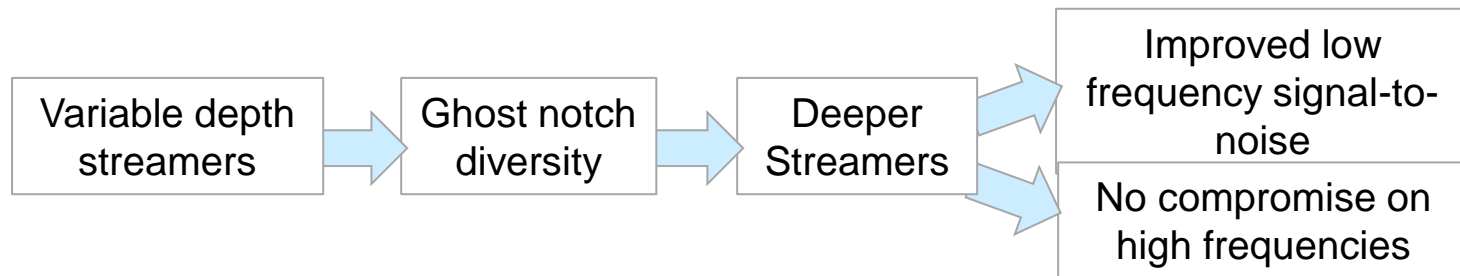- Data Management Services

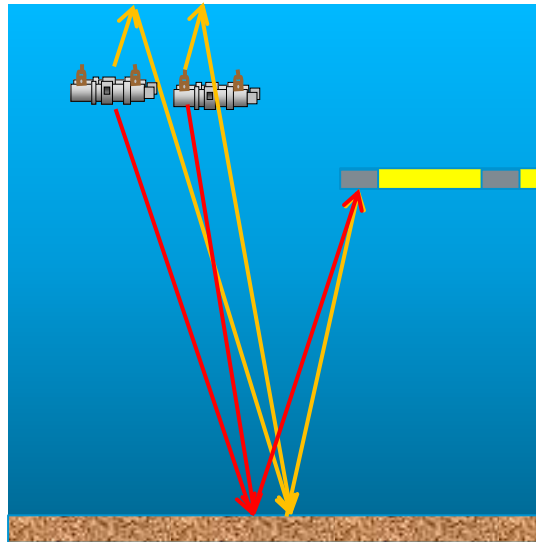*Seabed Geosolutions joint venture 60%-owned by Fugro and 40% by CGG

BroadSeis - The Broadest Marine Bandwidth

Optimal low frequencies are achieved by reducing the zero Hz ghost notch as much as possible for both source and receivers
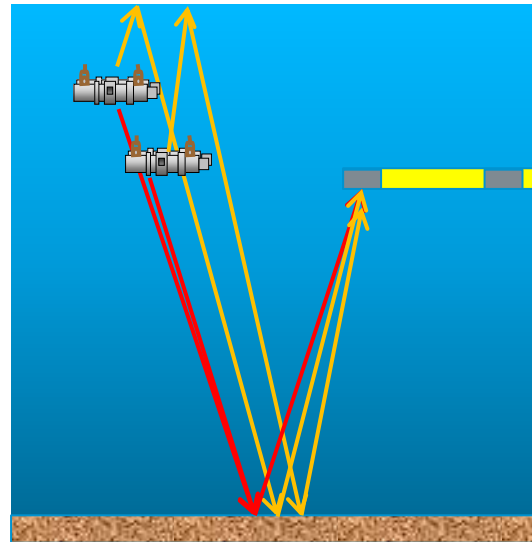
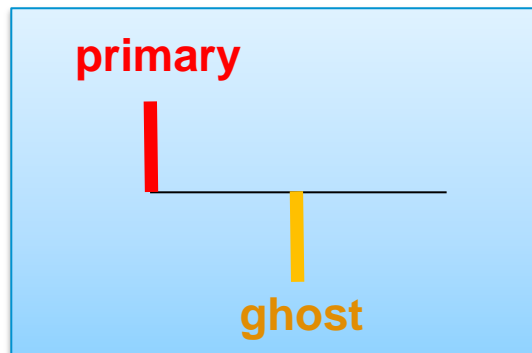The deeper the hydrophone tow depth the better the low frequency signal

| Variable depth streamers | → | Ghost notch diversity | → | Deeper Streamers | → | Improved low frequency signal-to-noise |
| | | | | | | No compromise on high frequencies |

Sea Surface

cable

frequency

Signal

Noise

BroadSource removes the source ghost

Tuning of primaries as well as their ghosts

Tuning of primaries by defocusing their ghosts

primary

ghost

primary

ghosts

Conventional Source

Multi-level Source

- A synchronized multi-level source – ghost-free data with no upper limit on bandwidth
- All the advantages of a conventional source
  - Mechanically reliable
  - Stable and repeatable signature
  - Good directivity (3D/ 4D)
  - Flip Flop compatible (3D)
  - No ghost notches
  - No compromise on Low Frequencies
- BroadSeis + BroadSource delivers the widest available bandwidth: 2.5 to 200 Hz (more than 6 octaves)
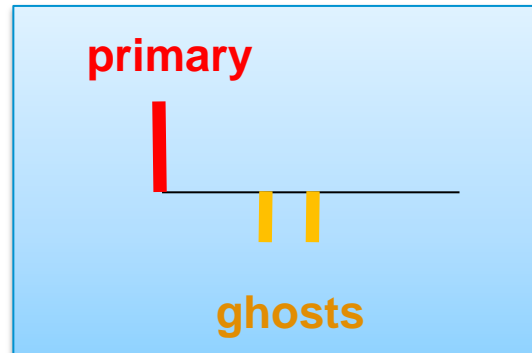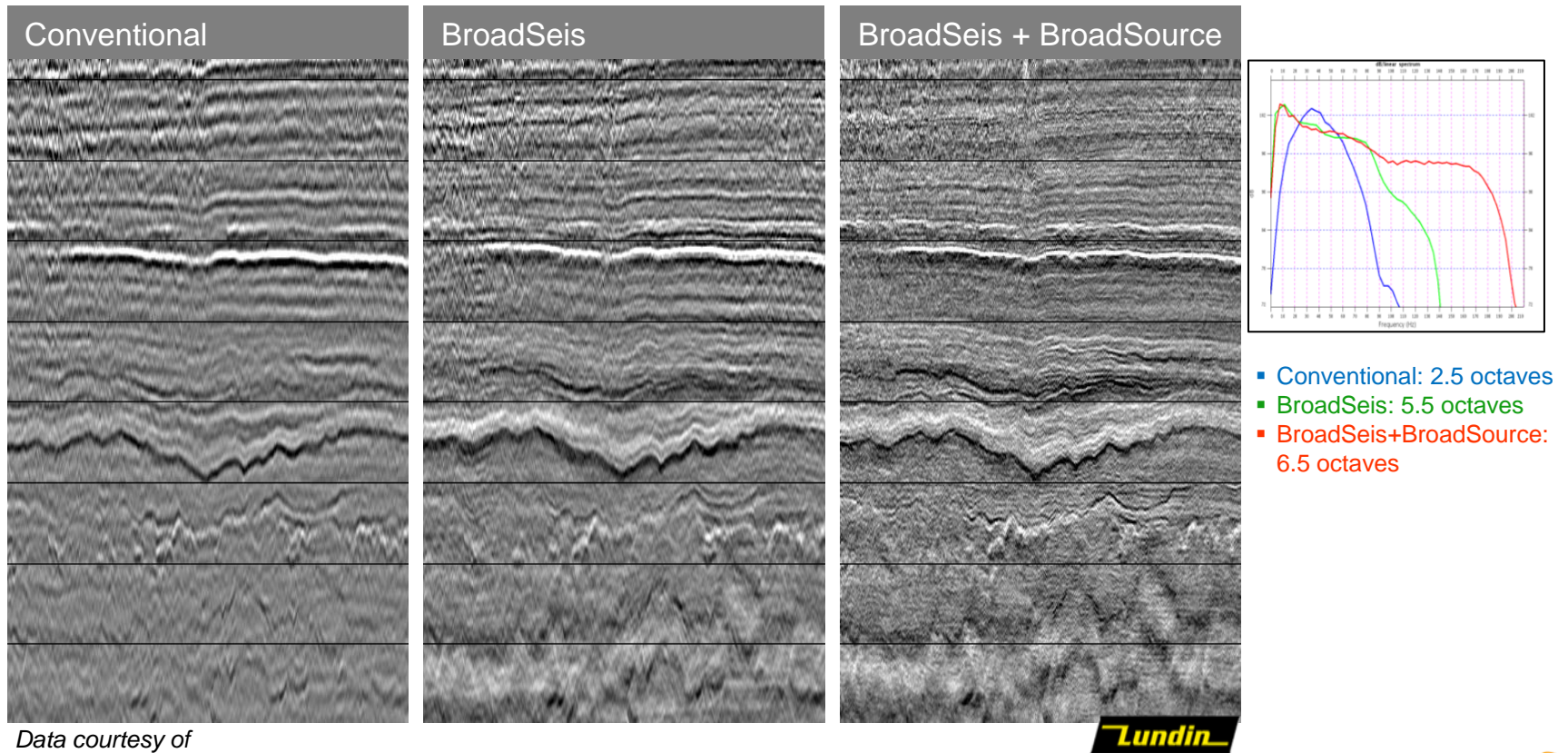
BroadSource: Fine detail from over 6 octaves of signal

The sharpest wavelets from BroadSeis with BroadSource for the best images

- Conventional: 2.5 octaves
- BroadSeis: 5.5 octaves
- BroadSeis+BroadSource: 6.5 octaves

Data courtesy of Lundin

# StagSeis - Long-offset, full-azimuth broadband seismic

- Acquired in asymmetric staggered formation (patents pending)

- Better noise and multiple attenuation from full azimuth to 9km

- Better illumination from inline offsets to 18km

- Linear tow – antiparallel & orthogonal

- Regular offset/azimuth per bin

- Asymmetric pattern for reciprocity
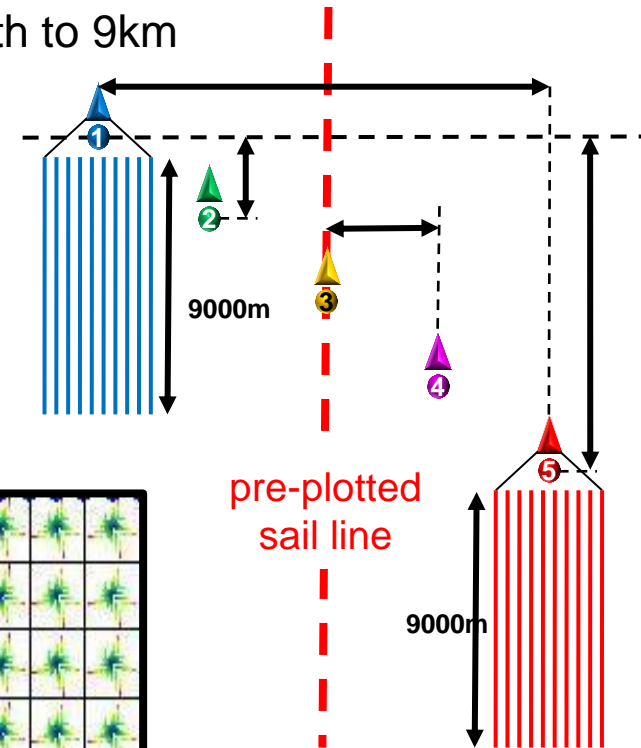
9000m

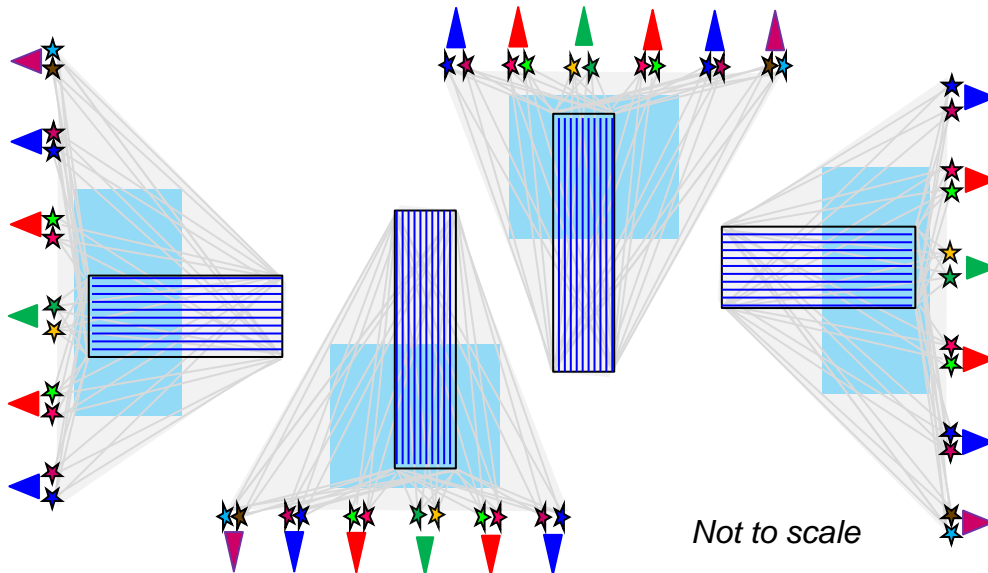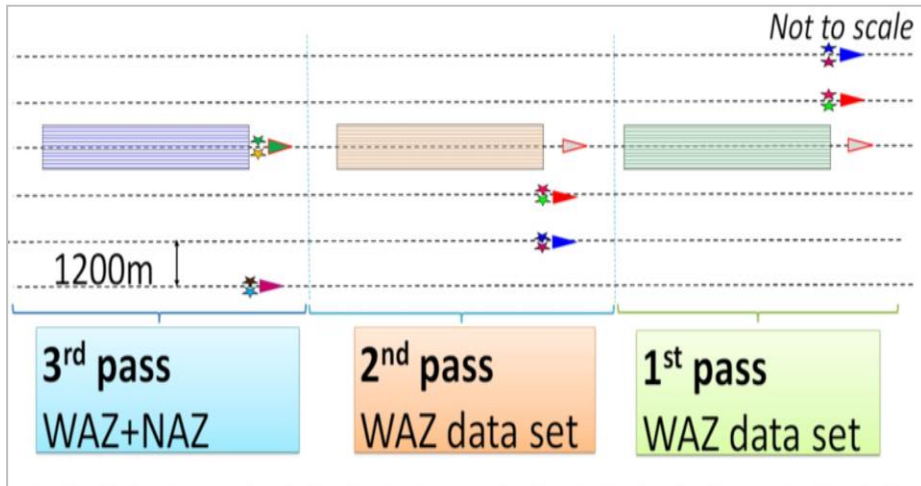pre-plotted sail line

9000m
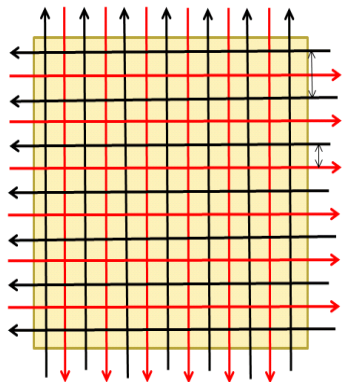
Linear tow – antiparallel & orthogonal
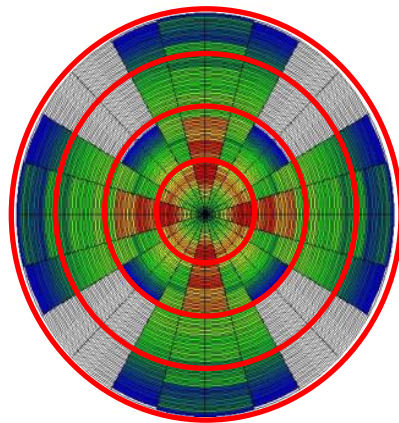
Full azimuth to 9m, ultra-long offsets to 18m on 4 axes
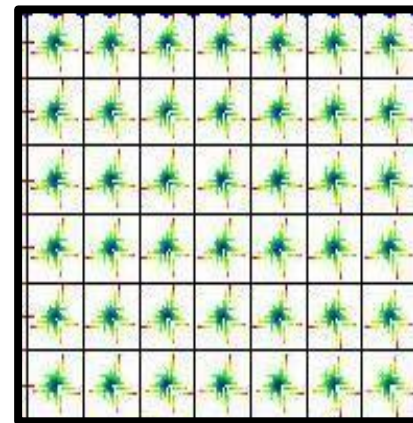
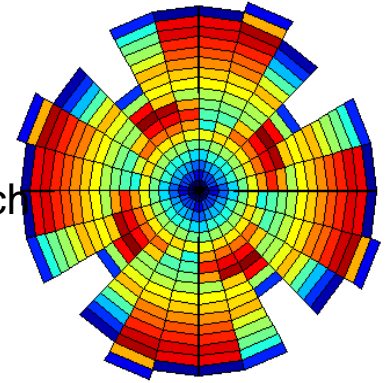Regular fold, offsets and azimuths in each processing bin

B-WATS

Not to scale

1200m

3rd pass
WAZ+NAZ

2nd pass
WAZ data set

1st pass
WAZ data set

B-WATS
  4 sources
x 12 streamers
x 3 passes on each
of 4 headings

Benefits

- Lower operational HSE exposure (compared with conventional "Mad-Dog" WAZ)

- Higher shooting plan flexibility (1/3 of time acquisition with just one source vessel)

- Higher availability for source maintenance

- Shorter acquisition time

Not to scale